Esri Response to NASA Request for Information - Preparation for the Development of a Community-Based Roadmap for NASA's Planetary Data Services

Response to Topic 6

6. What role should the PDS play in encouraging the development of higher-order data products and ensuring archive quality is quickly achieved?

• Name of submitter and contact information (institutional affiliation, E-mail address);

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NASA has been a valued Esri customer for over 20 years. Esri's full ArcGIS product stack is available to the majority of the scientific community at no additional cost, including all NASA and USGS missions. The majority of academic institutions worldwide maintain educational site licenses which also give their staff and students unlimited access to the ArcGIS Platform. Finally, qualified nonprofit organizations and individuals of the public can receive the full analytics product stack for as little as $150. In addition to the powerful analytics and serving components above, ArcGIS includes a free viewing applications (such as StoryMaps and ArcGIS Earth) for the public to interact with and query the data. Further, ArcGIS has a full suite of free and open Software Development Toolkits (SDKs) and Application Programmer Interfaces (APIs) that scientists can use to develop custom clients.

Since 1969, Esri has helped organizations map and model our world. Our GIS technology allows users to effectively manage and analyze geographic information so they can make better decisions. We offer flexible, configurable, and easy-to-use geospatial solutions that let anyone access informative maps and location apps anywhere and on any platform or device. These solutions are supported by our experienced staff and extensive network of business partners and international distributors.

Esri applications provide the backbone for the world's mapping and location analysis. Esri software is used in more than 350,000 organizations worldwide including each of the 200 largest cities in the United States, more than two-thirds of Fortune 500 companies, more than 24,000 state and local governments worldwide, and many others in dozens of industries. Private ownership, a zero-debt policy, and a firm commitment to fulfilling the needs of our customers all help Esri maintain its position as the world leader in GIS software.

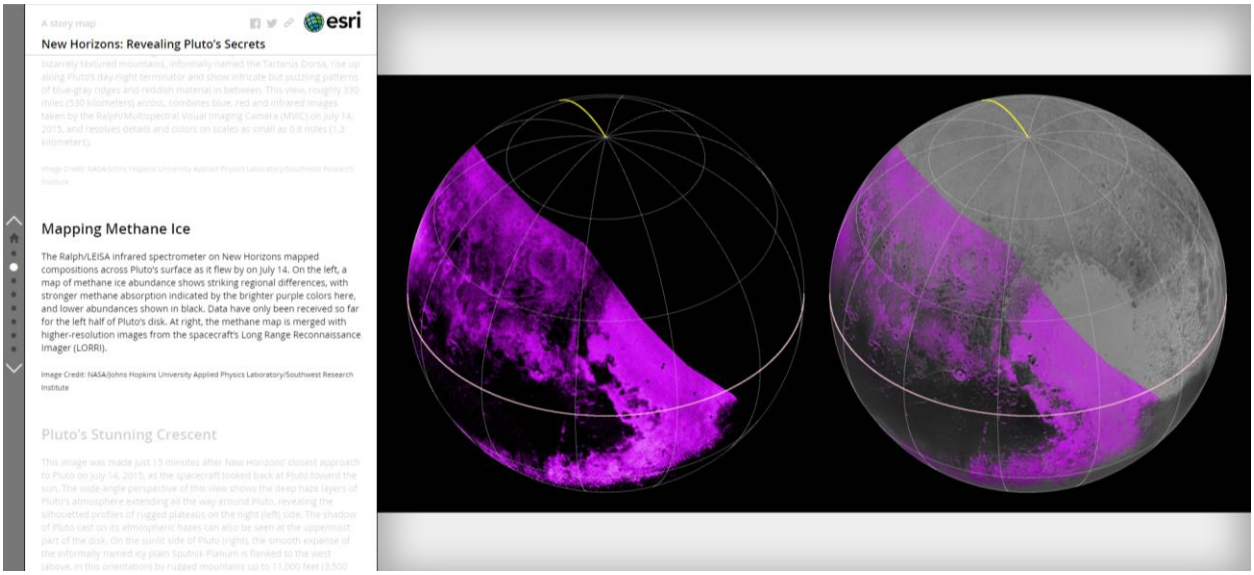
As a socially conscious business, we are proud that our technology is used by many organizations who apply location-based insights to solve problems and make our world a better place to live. We also actively support organizations involved in education, conservation, sustainable development, and humanitarian affairs.

• A clear and concise statement of the topic addressed;

The PDS needs to be able to integrate PDS multidimensional and imagery data products with cartographic products from missions and the Astrogeology Science Center (ASC) in a sustainable way, especially one that will be guaranteed to persist over the next 10 years. It can accomplish this using Esri's open ArcGIS platform, which is already in use at the USGS ASC and the PDS Geosciences Node.

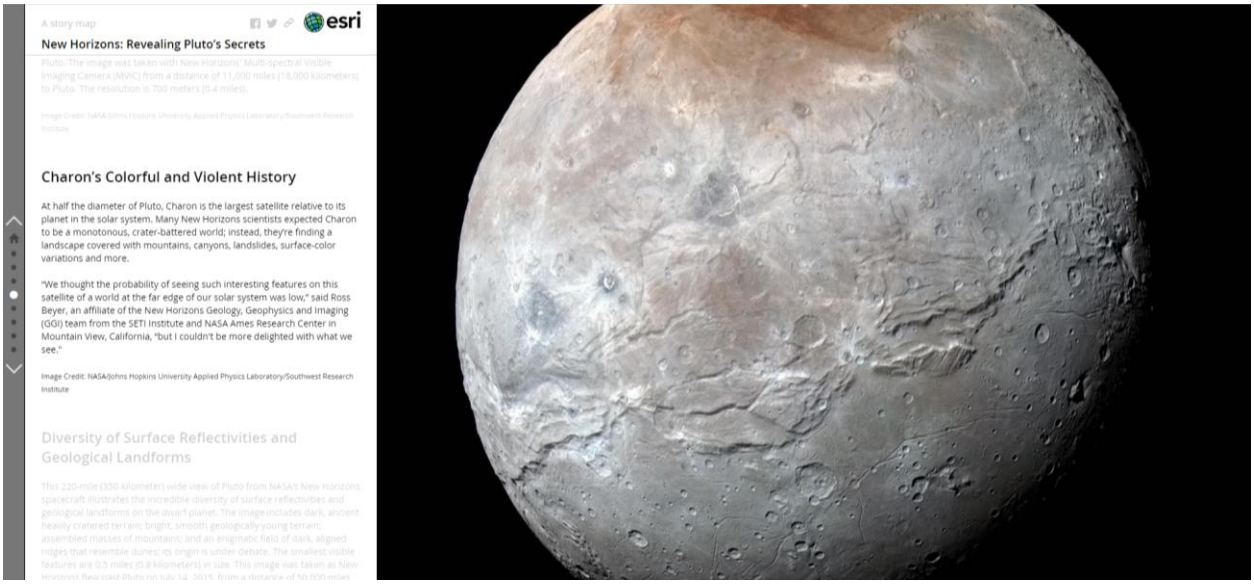
As the PDS reemphasizes the need to share data and make it accessible to a wider range of users, it becomes increasingly important to allow data from multiple sources to be integrated together. This allows you to create higher order data products, such as digital elevation models, soil and atmospheric composition analysis, and planetary imagery basemaps. This integration can only occur if data is held in standardized data formats, ideally made accessible through open APIs and SDKs. (For more information about data standardization, see Esri's response to question 1.) Open APIs and SDKs will allow various systems to communicate and share data with each other. By managing data in industry-standard file formats and databases, the PDS can increase the usability of its data for the creation of higher order data products in a GIS, increasing its longevity.

In the image of Pluto below, the methane map is merged with higher-resolution images from the spacecraft's Long Range Reconnaissance Imager (LORRI).



Methane Ice on Pluto

High resolution imagery is useful for visualization and high-quality planetary basemaps.



High resolution image of Charon

Below, this 220-mile (350-kilometer) wide view of Pluto from NASA's New Horizons spacecraft illustrates the incredible diversity of surface reflectivity and geological landforms on the dwarf planet.

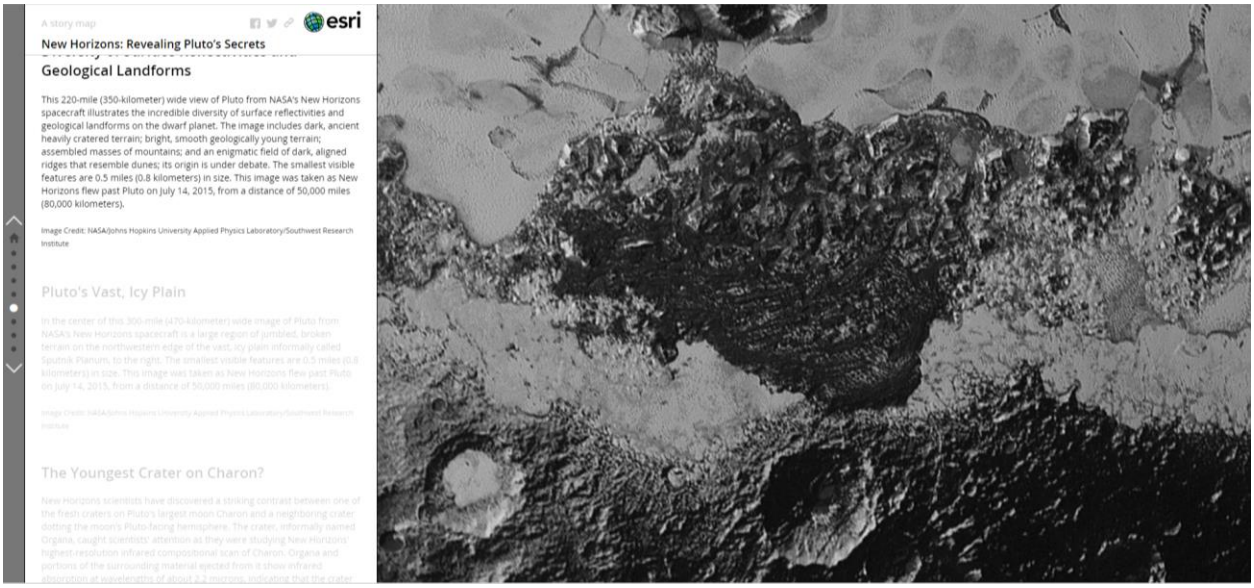


Image of surface of Pluto from New Horizons

• An articulate and compelling rationale for why the chosen topic would be significant to a wide range of planetary scientists;

Data sharing is an important part of any scientific work, including NASA's. Without access to the right data, planetary scientists, educators, research institutions, and citizen scientists cannot perform their work or reach complete, verifiable conclusions. But making data accessible requires more than putting

data on a server. Rather, this data needs to be available in a format or managed in a system that makes it easy to integrate into other software platforms and research projects for higher order analysis.

Many systems work with data that are stored in specific common formats, held in common databases, or accessible through open APIs. If data is held in a closed proprietary format, or locked in a system that cannot share information, then that data might as well not exist, because it cannot be readily used by the scientific community. Leveraging ArcGIS to adhere to common and open formats for data management will allow the PDS to publish workable data; as long as other agencies and organizations do the same, the PDS will be able to work with their data, too.

• Suggested improvements or changes relevant to the topic;

We recommend the PDS use Esri's ArcGIS platform to help keep its data accessible and easy to integrate. ArcGIS, the industry leader in cartographic software, is used by the Astrogeology Science Center and PDS Geosciences node, as well as many NASA Sciences missions, so its use would benefit these scientists. As a privately held, stable company, Esri offers a software platform that will continue to evolve over the next 10 years. ArcGIS is freely available to employees and contractors working at NASA, the DOI, and most universities around the world, and is already leveraged by many foreign space agencies and non-governmental organizations.

ArcGIS for Server allows you to store data in many common databases (including ALTIBASE, IBM DB2, IBM Informix, Microsoft Azure SQL Database, Microsoft SQL Server, Netezza, Oracle, PostegreSQL, SAP HANA, SQLite, and Teradata), which makes this data easy to integrate into other software platforms and research projects. ArcGIS also supports more than a hundred common file formats for data (including NetCDF, HDF4, HDF5, GRIB, and LERC/MRF), which helps you share and integrate data files. In addition, ArcGIS lets you publish data as web services and access this data through open APIs; this makes it easy for other systems to query and integrate data stored within ArcGIS.

Esri's ArcGIS APIs and SDKs are freely available and accompanied by large GitHub repositories. These APIs and SDKs are also maintained and evolved alongside their respective technologies by the Esri developer team.

Finally, Esri is committed to making ArcGIS an open system. Esri participates actively in the Open Geospatial Consortium (OGC) and other standards bodies, incorporating support for new standards as they develop. This means ArcGIS for Server can serve and consume big data formats as well as industry-standard formats like WMS.

Esri is also actively collaborating with NASA on improving cloud GIS technologies. A notable example is the development of the Meta Raster Format (MRF), a cloud-aware tiled raster format. The MRF associated OnEarth web server is another such collaboration area, software which has been initially developed at JPL, and despite the name, has been used in planetary services, as OnMars and OnMoon.

More recently, Esri released in the open source the Limited Error Raster Compression (LERC) a fast data compression algorithm ideally suited for raster data web application. While these tools are open software, they are especially well integrated in the Esri family of products, encouraging data sharing and interoperability. We strongly recommend that PDS leverage these technologies.

• A discussion of the impact of not making the suggested improvements or changes; and,

If the PDS does not take ease of integration into account, then it will have a more difficult time engaging with the public, sharing data with educators and research institutions, and contributing to the ConnectED initiative. Data storage costs also have the potential to be greater without optimized web service compression.

• A discussion of the potential impacts of the suggested improvements or changes.

The PDS will more easily engage with the public; share data with educators, scientists, and research institutions; and contribute to the ConnectED initiative.